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Solving a Multistage Transportation Problem Using LINGO

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Abstract

Transhipment is the shipment of goods or containers to an intermediate destination, and then from there to yet another destination. One possible reason is to change the means of transport during the journey (for example from ship transport to road transport), known as transloading. Another reason is to combine small shipments into a large shipment (consolidation), dividing the large shipment at the other end (deconsolidation). Transshipment usually takes place in transport hubs. Much international transshipment also takes place in designated customs areas, thus avoiding the need for customs checks or duties, otherwise a major hindrance for efficient transport. Transshipment problems form a subgroup of transportation problems, where transshipment is allowed. In transshipment, transportation may or must go through intermediate nodes, possibly changing modes of transport. In this paper we consider a simple multistage transportation problem and solve it using LINGO package.

Keywords: *Transhipment, shipment, goods, transloading, transport, LINGO.*

1. Introduction

Transshipment or Transhipment is the shipment of goods or containers to an intermediate destination, and then from there to yet another destination. One possible reason is to change the means of transport during the journey (for example from ship transport to road transport), known as transloading. Another reason is to combine small shipments into a large shipment (consolidation), dividing the large shipment at the other end (deconsolidation). Transshipment usually takes place in transport hubs. Much international transshipment also takes place in designated customs areas, thus avoiding the need for customs checks or duties, otherwise a major hindrance for efficient transport. Transshipment problems form a subgroup of transportation problems, where transshipment is allowed. In transshipment, transportation may or must go through intermediate nodes, possibly changing modes of transport. The Transshipment problem has its origins in medieval times when trading started to become a mass phenomenon. Obtaining the minimum-cost route had been the main priority. However, technological development slowly gave priority to minimum-duration transportation problems. The classical transportation problem can be applied in a more general way in practice. Related problems as Multi-commodity transportation problem, Transportation problems with different kind of vehicles, Multi-stage transportation problems, Transportation problem with capacity limit is an extension of the classical transportation problem considering the additional special condition. For solving such problems many optimization techniques (dynamic programming, linear programming, special algorithms for transportation problem etc.) and heuristics approaches (e.g. evolutionary techniques) were developed. In this paper we consider a simple multistage transportation problem and solve it using LINGO package.

2. Literature Review

Anand Jayakumar A and Krishnaraj C [1] have created a mathematical revenue model for multiple customer segments. Anand Jayakumar A et al [2] have optimized a p median problem using python. Anand Jayakumar A et al [3] have optimized a fixed charge problem using python. Anand Jayakumar A and Krishnaraj C [4] have created a mathematical model for pricing and revenue management of perishable assets. Anand Jayakumar A and Krishnaraj C [5] have suggested on implementation of quality circle. Anand Jayakumar A et al [6] have suggested a mixed strategy for aggreage planning. Anand Jayakumar A et al [7] have created a mathematical model for aggregate planning. Anand Jayakumar A et al [8] have created a mathematical model for supply chain network design. Anand Jayakumar A et al [9] have created a mathematical model for aggregate planning for a pump manufacturing company. Anand Jayakumar A et al [10] have improved productivity in a stitching section. Anand Jayakumar A et al [11] have created another model for aggregate planning. Anand Jayakumar A et al [12] have reviewed on the mathematical models for supply chain network design. Anand Jayakumar A et al [13] have created a chase strategy for aggregate production planning. Anand

Jayakumar A and Krishnaraj C [14] have created a mathematical model for supply chain network optimization using gravity location method. Krishnaraj C et al [15] have solved a supply chain network optimization model. Anand Jayakumar A et al [16] have presented a supply chain location allocation problem in multiple stages and dedicated supply. Anand Jayakumar A et al [17] have presented a facility layout problem.

3. Mathematical Model

We consider the transportation of a single commodity through a multistage process. The items can be transported from factories to intermediate warehouses and then to retailers. In a two-stage transportation problem, we transport all the materials to warehouses from which they are transported to retailers.

Consider a two-stage transportation problem as follows:

X_{ij} = Quantity supplied from factory i to warehouse j
Y_{jk} = Quantity transported from warehouse j to retailer k
C_{ij} = Unit cost of transportation from factory I to warehouse j
C_{jk} = Unit cost of transportation from warehouse j to retailer k
a_i = Quanity available in factory i
b_k = Quanity required by retailer k

The objective is to

Minimize $\sum_i \sum_j \; Cij \; Xij \; \sum_j \quad \sum_k Cjk \; Yjk$

Subject to

$\sum_j Xij \leq a_i$ where i = 1….m

$\sum_i \; Xij \geq \sum_k \; Yjk$ where j = 1….p

$\sum_j Xij \geq b_k$ where k = 1….n

Xij, Yjk ≥ 0

4. The Problem

A two stage transportation problem with three factories (F1 to F3), two warehouses (W1 and W2) and three retailers (R1 to R3). The supplies in the factories are 100, 80 and 60 and the demands at the retailers are 90, 70 and 80. The warehouses have infinite capacity. The transportation cost is given in Table 1.

Table 1: Data for a two-stage transportation problem

No.	From-to	Cost
1	F1 – W1	8
2	F1 – W2	7
3	F2 – W1	9
4	F2 – W2	5
5	F3 – W1	7
6	F3 – W2	4
7	W1 – R1	10
8	W1 – R2	5
9	W1 – R3	9
10	W2 – R1	8
11	W2 – R2	6
12	W2 – R3	3

5. About LINGO

LINGO is a simple tool for utilizing the power of linear and nonlinear optimization to formulate large problems concisely, solve them, and analyze the solution. Optimization helps you find the answer that yields the best result; attains the highest profit, output, or happiness; or achieves the lowest cost, waste, or discomfort. Often these problems involve making the most efficient use of your resources—including money, time, machinery, staff, inventory, and more. Optimization problems are often classified as linear or nonlinear, depending on whether the relationships in the problem are linear with respect to the variables. LINGO includes a set of built-in solvers to tackle a wide variety of problems. Unlike many modeling packages, all of the LINGO solvers are directly linked to the modeling environment. This seamless integration allows LINGO to pass the problem to the appropriate solver directly in memory rather than through more sluggish intermediate files. This direct link also minimizes compatibility problems between the modeling language component and the solver components. Local search solvers are generally designed to search only until they have identified a local optimum. If the model is non-convex, other local optima may exist that yield significantly better solutions. Rather than stopping after the first local optimum is found, the Global solver will search until the global optimum is confirmed. The Global solver converts the original non-convex, nonlinear problem into several convex, linear subproblems. Then, it uses the branch-and-bound technique to exhaustively search over these subproblems for the global solution. The Nonlinear and Global license options are required to utilize the global optimization capabilities.

6. LINGO Program

```
Model:
Min = 8*X11 + 7*X12 + 9*X21 + 5*X22 +
7*X31 + 4*X32 + 10*Y11 + 5*Y12 + 9*Y13
+ 8*Y21 + 6*Y22 + 3*Y23;

X11 + X12 <= 100;
X21 + X22 <= 80;
X31 + X32 <= 60;
Y11 + Y21 >= 90;
Y12 + Y22 >= 70;
Y13 + Y23 >= 80;

Y11 + Y12 + Y13 - X11 - X21 - X31 <= 0;
Y21 + Y22 + Y23 - X12 - X22 - X32 <= 0;

@GIN(X11);@GIN(X12);@GIN(X21);@GIN(X22)
;@GIN(X31);@GIN(X32);
@GIN(Y11);@GIN(Y12);@GIN(Y13);@GIN(Y21)
;@GIN(Y22);@GIN(Y23);

End
```

7. Result and Discussion

Table 2: Result

Source	Destination	Quanity
Factory 1	Warehouse 1	70
Factory 1	Warehouse 2	30
Factory 2	Warehouse 2	80
Factory 3	Warehouse 3	60
Warehouse 1	Retailer 2	70
Warehouse 2	Retailer 1	90
Warehouse 2	Retailer 3	80

8. Conclusion

Thus we have solved the multistage transportation problem using linear programming method.

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